

# DEF – SCR Training Module

February 13, 2009



**Filtration**

## DEF – SCR Training Module

Welcome to the Cummins Filtration DEF – SCR introductory training module.

DEF – SCR systems are a strategic methodology to Cummins meeting the 2010 On-Highway emission requirements.

## DEF – SCR Training Module

The following training module will prepare you to discuss the basic aspects of this new technology with your customers. Familiarize yourself with the individual objectives as well as the message triangle. This will ensure all Cummins and Cummins Filtration representatives are telling the same story.

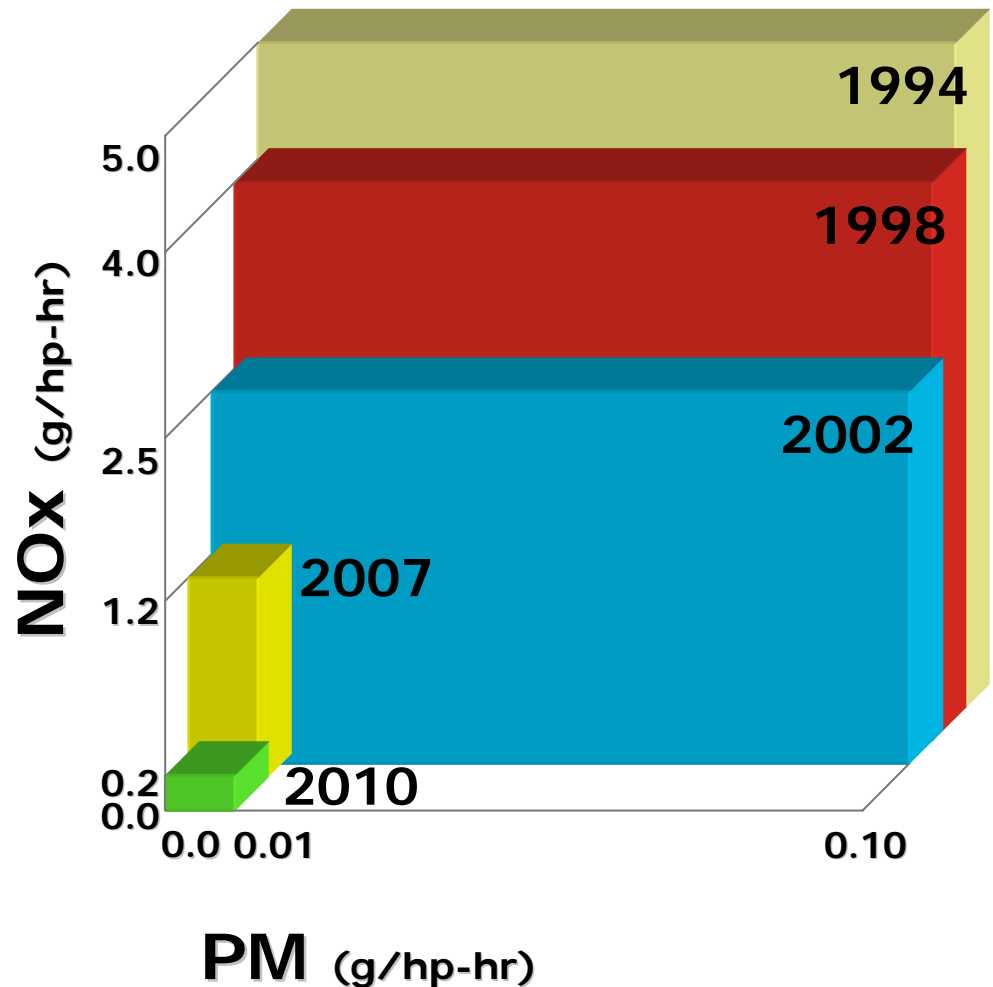
## DEF – SCR Training Module Objectives:

- Objective 1: To become familiar with DEF and SCR systems.
- Objective 2: To gain further knowledge of DEF.
- Objective 3: To understand Cummins Filtration's role in DEF supply.
- Objective 4: To become familiar with the DEF - SCR message triangle.

Objective 1: To become familiar with DEF and SCR systems.

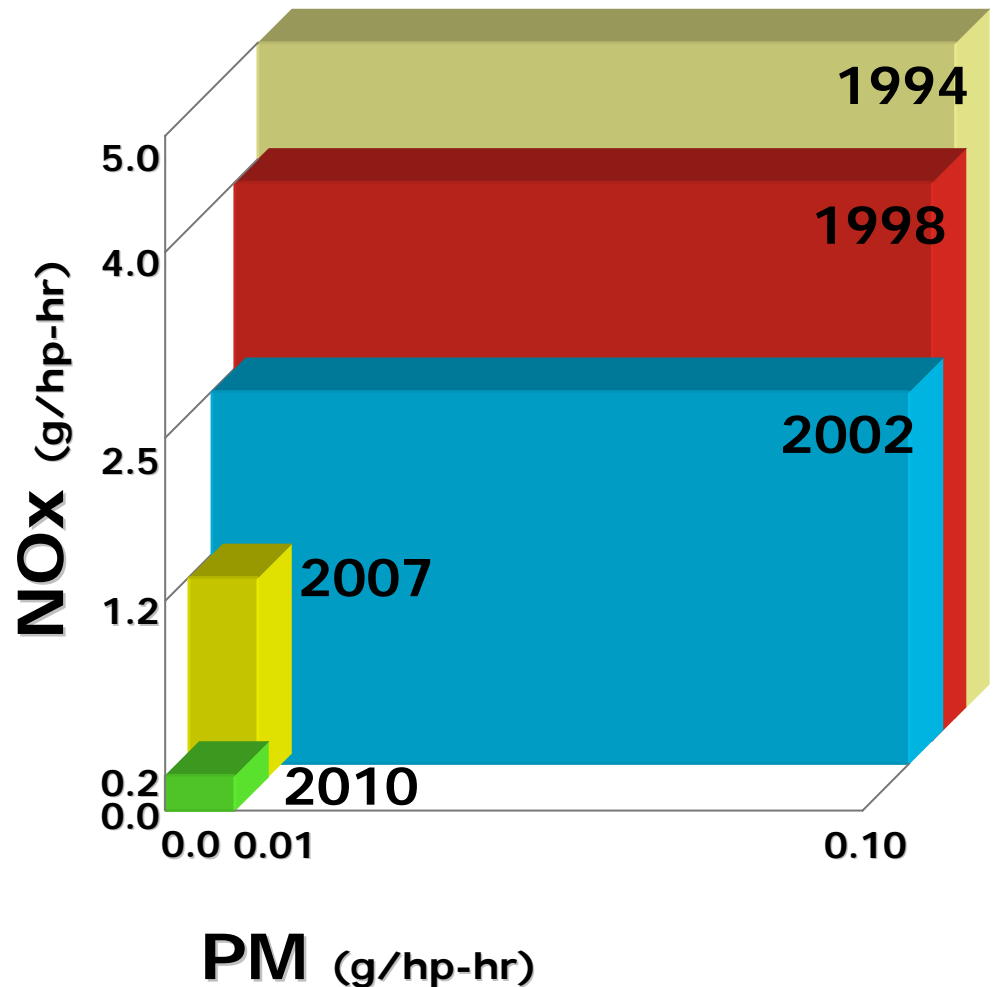
Objective 1: To become familiar with DEF and SCR systems.

The 2010 heavy-duty emission standards for North America are: 0.2g/HP-hr NO<sub>x</sub> and 0.01 g/HP-hr Particulate Matter (PM).



Objective 1: To become familiar with DEF and SCR systems.

This is a reduction of emissions by 98% since the late 1980's.



Objective 1: To become familiar with DEF and SCR systems.

Cummins has committed to providing a complete lineup of certified and compliant on-highway engine products that will meet the 2010 emission standards.



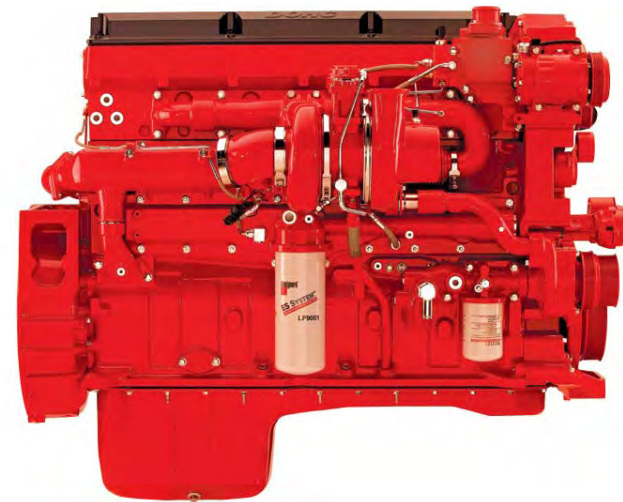
Objective 1: To become familiar with DEF and SCR systems.

Cummins will be building on the technology that it currently has in the marketplace. Building on its successes with cooled Exhaust Gas Recirculation (EGR) introduced in 2002 and the Cummins Particulate Filter introduced in 2007, Cummins will meet the 2010 emissions standards with the addition of Nitrogen Oxide (NO<sub>x</sub>) aftertreatment using Selective Catalytic Reduction (SCR) technology.



Objective 1: To become familiar with DEF and SCR systems.

SCR technology uses a urea based chemical called diesel exhaust fluid (DEF) and a catalytic converter to significantly reduce oxides of nitrogen (NOx) emissions.

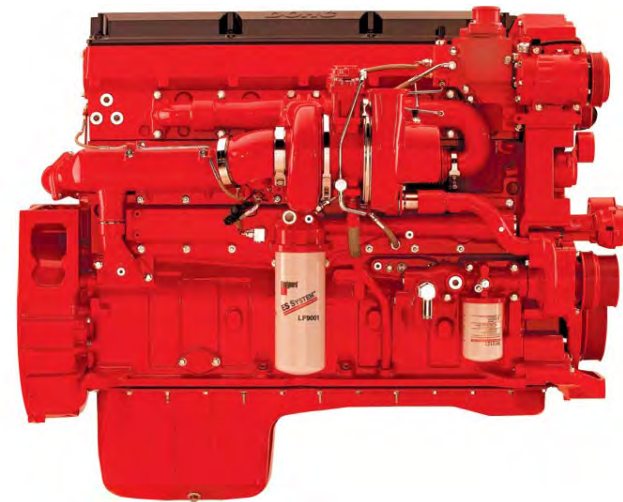


### SCR Catalyst

- Very high efficiency
- Thermal stability

Objective 1: To become familiar with DEF and SCR systems.

SCR technology is not new to Cummins and Cummins Filtration. In 2006, Cummins launched its midrange engines certified to the Euro 4 standard using SCR for commercial vehicle applications in Europe.

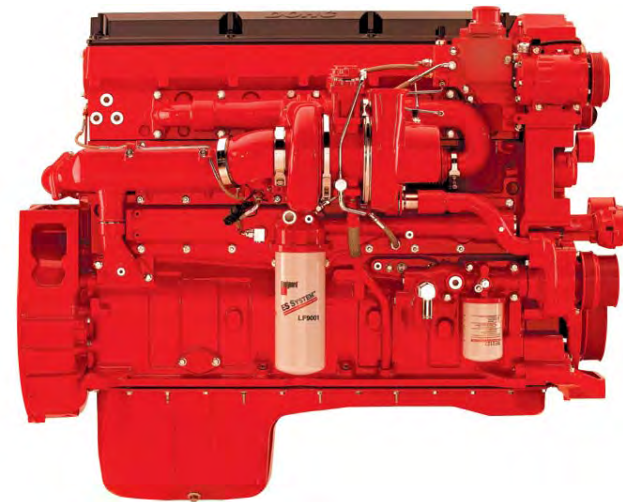


### **SCR Catalyst**

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Cummins has built and shipped over 45,000 SCR engines to date, and Cummins Emission Solutions has built and shipped over 200,000 SCR systems.

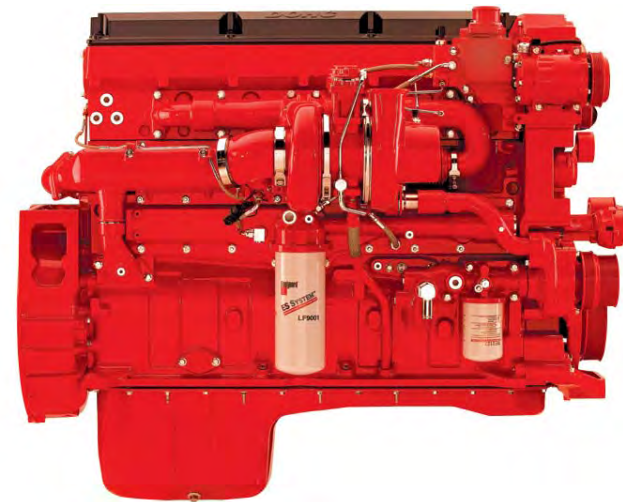


### **SCR Catalyst**

- Very high efficiency
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Objective 1: To become familiar with DEF and SCR systems.

Cummins Filtration has marketed a DEF product since 2003.

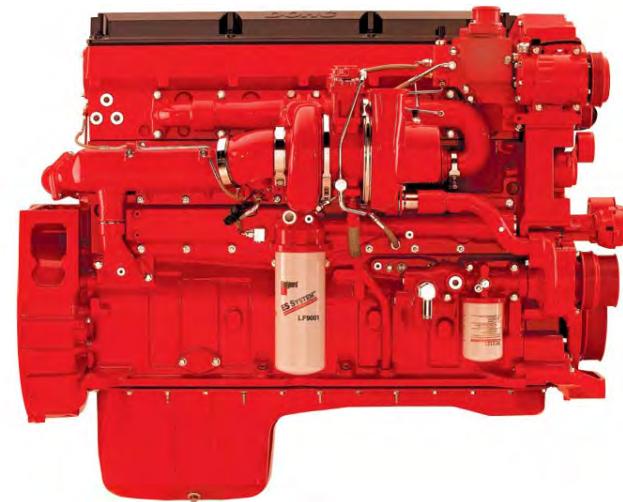


### SCR Catalyst

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Objective 1: To become familiar with DEF and SCR systems.

The DEF is injected into the hot exhaust gas stream where it vaporizes and decomposes to form ammonia and carbon dioxide. The ammonia ( $\text{NH}_3$ ) is the desired product which in conjunction with the SCR catalyst, converts the  $\text{NO}_x$  to Nitrogen ( $\text{N}_2$ ) and water ( $\text{H}_2\text{O}$ ).

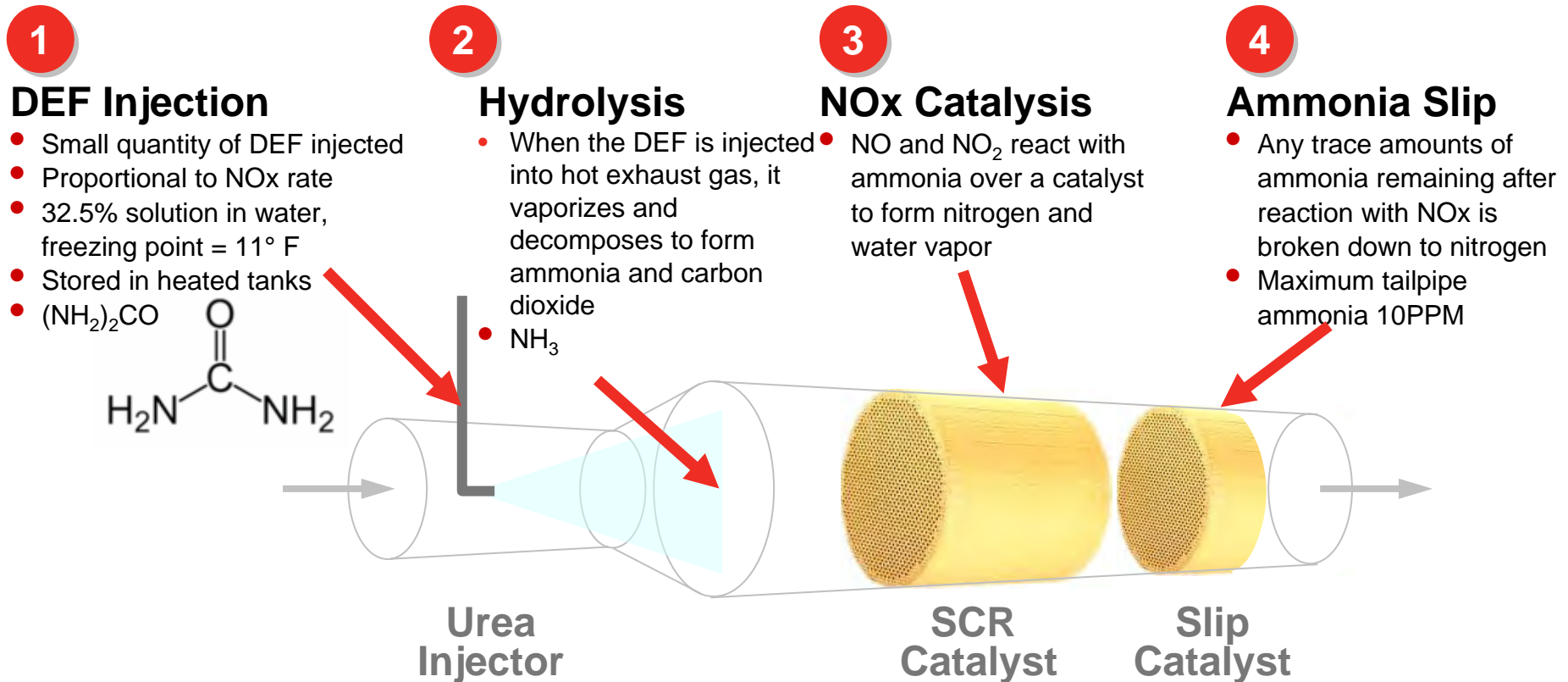


### SCR Catalyst

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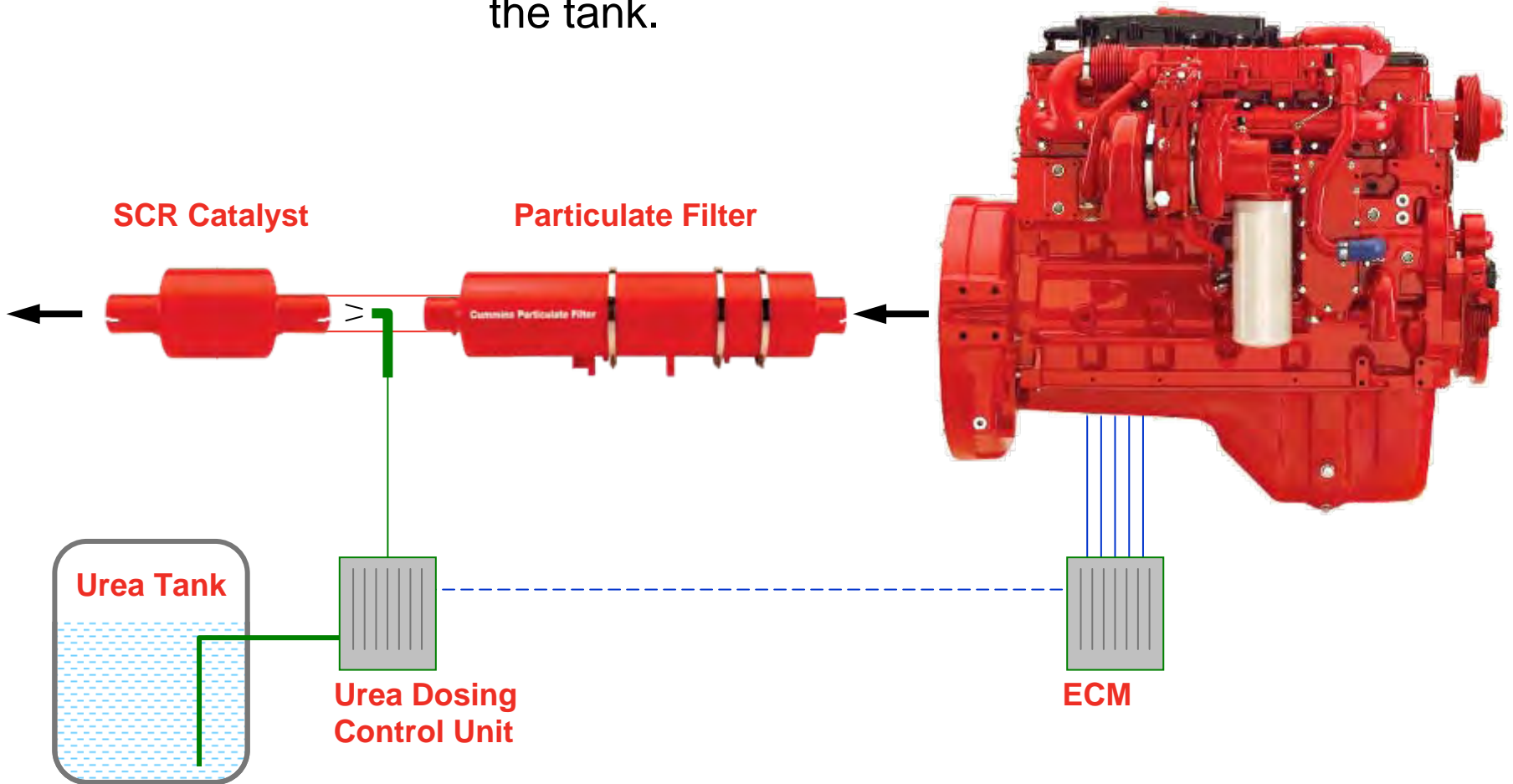
# Selective Catalytic Reduction Fundamentals

## Chemistry is well understood and controllable



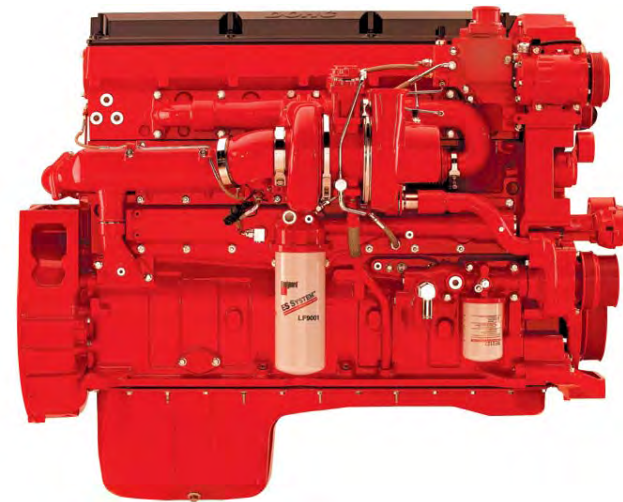
# Selective Catalytic Reduction

Cummins will provide all SCR components except the tank.



Objective 1: To become familiar with DEF and SCR systems.

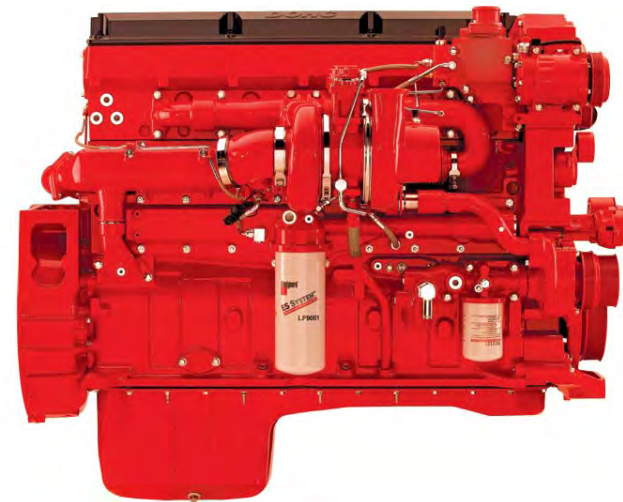
Cummins Heavy Duty engines utilizing an SCR system can deliver up to 5% improvement in fuel economy, primarily due to being the only engine manufacturer with the in-house capability to design, produce and integrate key engine and aftertreatment sub-systems.



**Note: Medium Duty engines will achieve the same great fuel economy as their 2007 predecessors.**

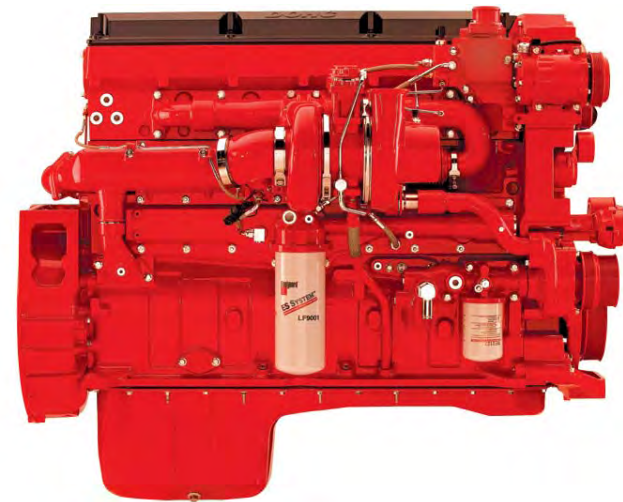
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Additionally, SCR catalyst technology allows much greater NO<sub>x</sub> conversion efficiency, thereby allowing the engine to be fully optimized, which contributes to this fuel economy improvement.



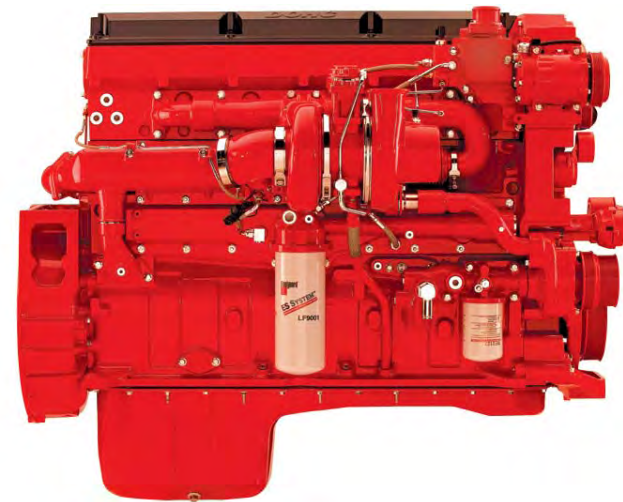
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Another benefit of the 5% reduction in fuel consumption is less frequent Diesel Particulate Filter (DPF) cleanout. (less fuel burned = less contaminant)



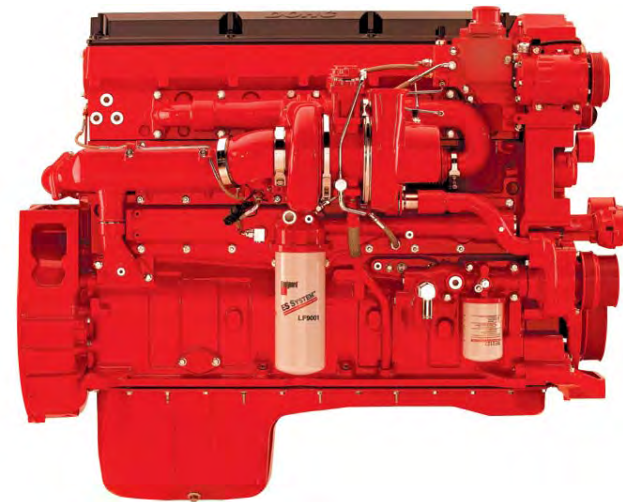
Objective 1: To become familiar with DEF and SCR systems.

Also, as the SCR system only impacts the exhaust stream, there will be no impact on the lubrication system and therefore, no changes to the service intervals.



Objective 1: To become familiar with DEF and SCR systems.

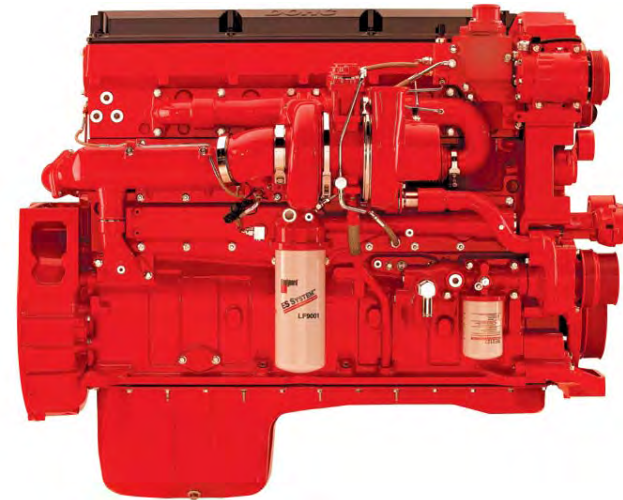
The combination of combustion design, fuel systems, air handling, aftertreatment, filtration and electronic controls, all in-house core technologies, puts Cummins in a very unique and strong market position.



Objective 1: To become familiar with DEF and SCR systems.

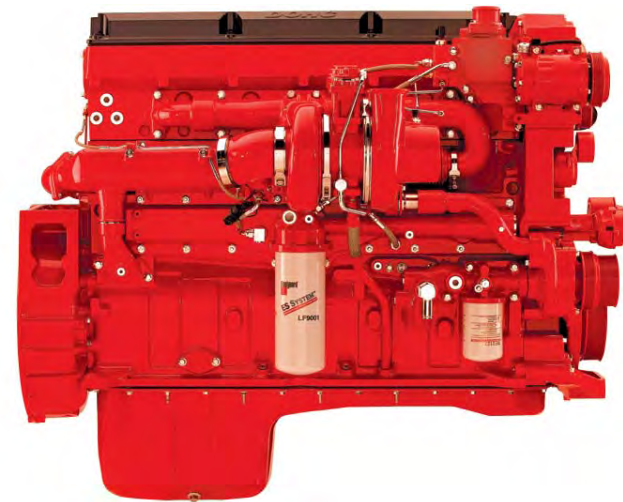
SCR systems allow maximum efficiencies to be gained in the combustion process, thereby improving:

- Fuel economy
- Stronger engine performance
- Faster throttle response
- Larger operating sweet spot
- Best in class drivability and reliability



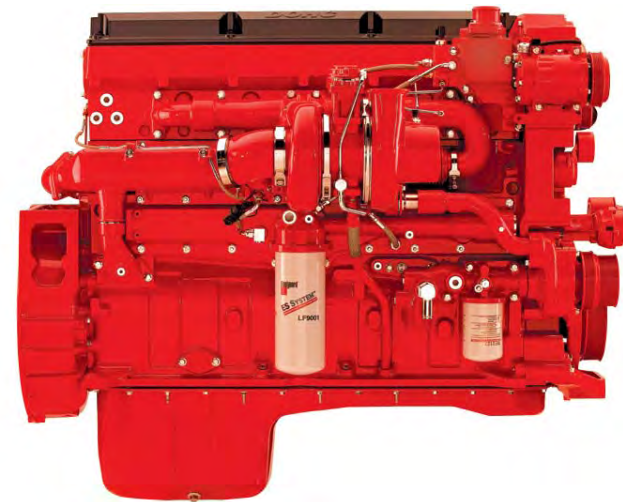
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It is key that the infrastructure for DEF be in place to support this move, and equally critical that we communicate with our customers that we have the technology, the products, and the experience to ensure this happens.



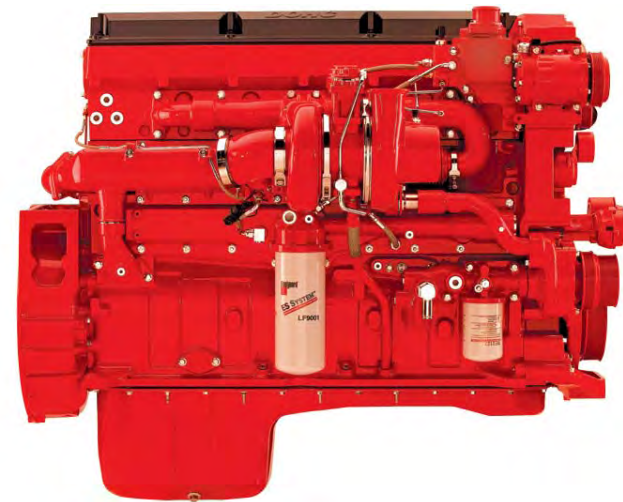
Objective 1: To become familiar with DEF and SCR systems.

All major truck stops have committed to carrying/supplying DEF at all their locations.



Objective 1: To become familiar with DEF and SCR systems.

- All other heavy duty engine manufacturers have chosen SCR as their emissions solution as well, with the exception of International
- Many 2009 diesel powered automobiles are also SCR equipped (Mercedes, BMW, et al) in North America



Objective 2: To gain further knowledge of  
DEF

Objective 2: To gain further knowledge of DEF

Diesel exhaust fluid (DEF) is the reactant necessary for the functionality of the SCR system. The primary reactants for DEF production are ammonia ( $\text{NH}_3$ ) and carbon dioxide ( $\text{CO}_2$ ).



**DEF is produced from natural gas, coal or other petroleum products.**

Objective 2: To gain further knowledge of DEF

Pure urea is solid at room temperature. DEF is prepared by dissolving solid urea to create a 32.5% solution in water.



Objective 2: To gain further knowledge of DEF

The solution has high purity requirements which are defined by the German Institute of Standardization DIN 70700 and the International Organization for Standardization ISO 22241-1.



There will also be an American Petroleum Institute (API) certification.

Objective 2: To gain further knowledge of DEF

While urea is used commonly in agriculture, the formula used in an SCR system as DEF is a highly purified specially made liquid.

End-users and operators will not be capable of producing their own DEF.



Objective 2: To gain further knowledge of DEF

A 32.5% solution of DEF will freeze at 11 degrees F, (-11 C).

This is the ideal solution as it allows the lowest freeze point and in the event the solution does freeze, the urea and water will freeze at the same rate, ensuring the solution does not become diluted.



Objective 2: To gain further knowledge of DEF

The installation of an SCR system will provide for heating of the DEF tank and supply lines.

The system will be designed to operate properly in cold climates.



**Note: If DEF freezes, it can be thawed and used. DEF is not damaged or destroyed from being frozen.**

**Recommended storage of DEF is between 40 and 80 deg F  
(4 to 27 deg. C)**

Objective 2: To gain further knowledge of DEF

It is important to note, that even in the event that the DEF supply is frozen, (in a vehicle) it will NOT impact the operators ability to start up and continue normal operation of the vehicle.



**An anti-gelling additive or freeze point improver must never be added to the DEF.**

Objective 2: To gain further knowledge of DEF

Cummins has tested the storage life of DEF for several years, and the International Organization for Standardization (ISO) has specification 22241-3 that details the storage, handling and shelf life minimum expectations throughout the distribution chain.



Objective 2: To gain further knowledge of DEF

- Storage temperature below 86 deg F, or 30 deg C is recommended to maintain shelf life
- Storage temperature above 11 deg F, or -11 deg C is recommended to avoid freezing



Objective 2: To gain further knowledge of DEF

- Shelf life of DEF is a function of ambient storage temperature
- Expectations for minimum shelf life are defined by ISO 2241-3 when stored at constant temperatures
- DEF will degrade in time depending on temperature and exposure to sunlight, which should be minimal



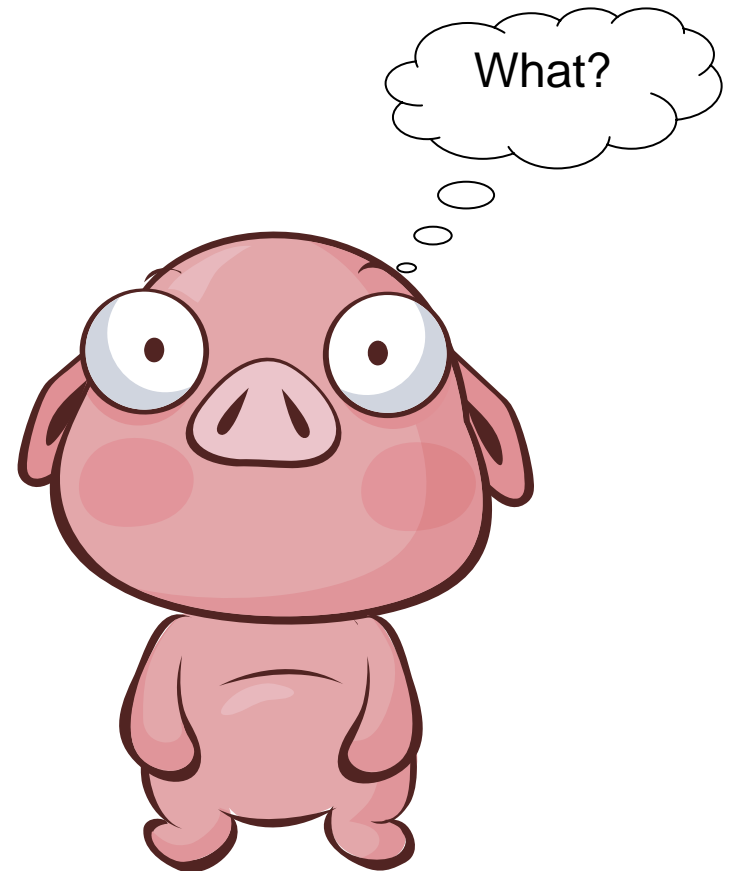
Objective 2: To gain further knowledge of DEF

- If stored between 10 and 90 deg F (-12 to 32 C) shelf life will be 1 year
- If the maximum temperature does not exceed 75 deg F (24 C) for an extended period of time, the shelf life could be two years



Objective 2: To gain further knowledge of DEF

While DEF may have a slightly pungent odor, similar to that of ammonia, it is non-toxic, non-polluting and non-flammable.



Objective 2: To gain further knowledge of DEF

DEF consumption is expected to be approximately 2% of fuel consumption, dependant on vehicle operation, duty cycle, geography, ratings etc.

**A heavy duty truck, averaging 120,000 miles annually, and achieving 6 mpg, would require approximately 400 gallons of DEF.**



Objective 2: To gain further knowledge of DEF

### Example: Medium Duty

- Annual miles for average truck = 50,000
- mpg for average truck = 10 mpg
- $50,000 \text{ miles} / 10 \text{ mpg} = 5,000 \text{ gallons diesel fuel per year}$
- DEF usage @ 2% of fuel consumption = 100 gallons of DEF/year
- 100 gallons / 10 gallon tank (average size) = 10 DEF fill-ups/year



Objective 2: To gain further knowledge of DEF

### Example: Heavy Duty

- Annual miles for average truck = 120,000
- mpg for average truck = 6 mpg
- $120,000 / 6 \text{ mpg} = 20,000$  gallons diesel fuel per year
- DEF usage @ 2% of fuel consumption = 400 gallons of DEF/year
- 400 gallons / 20 gallon tank (average size) = 20 DEF fill-ups/year




**A truck averaging 6 mpg can expect to travel approximately 300 miles on 1 gallon of DEF.**

Objective 3: To understand Cummins Filtration's role in DEF supply.

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Cummins Filtration has been marketing DEF since 2003 for use in stationary diesel engines.



**Fleetguard**  
Diesel Exhaust Fluid  
Aqueous Urea Solution for Your SCR NOx Reduction Systems

Designed specifically for modern Internal Selective Catalytic Reduction (SCR) NOx reduction systems, Fleetguard Diesel Exhaust Fluid (DEF) is carefully blended with high purity synthetic urea dissolved in deionized water. The finished formulation is further filtered to ensure maximum protection for Internal SCR system components.

**Formulated for SCR Protection**

- Reduces SCR component wear
- Extends SCR catalyst life

**Packaging Options to Meet Your Needs**

- Available in bulk, plastic and disposable totes, and plastic drums
- Bulk delivery from blending facility
- Smaller package sizes with built-in dispensing available in 2009

**Performance Tested**

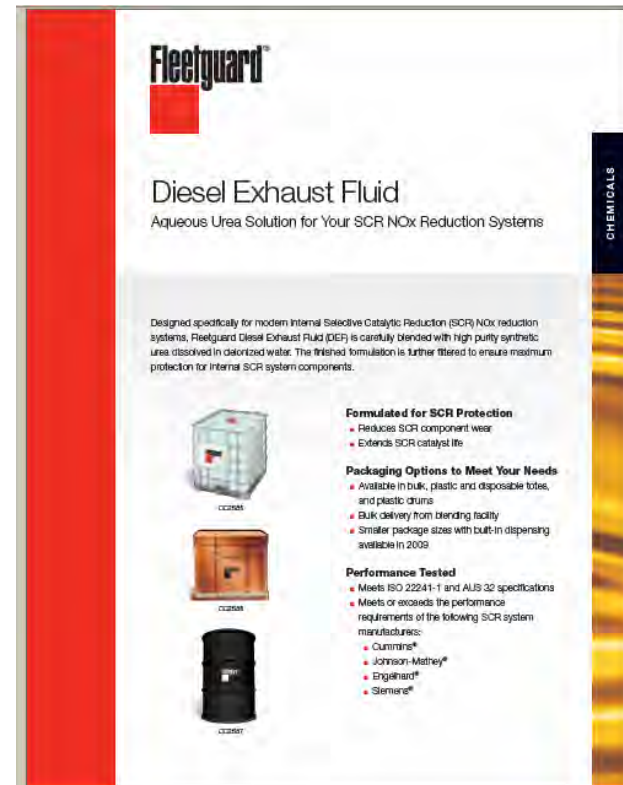
- Meets ISO 22241-1 and AUS 32 specifications
- Meets or exceeds the performance requirements of the following SCR system manufacturers:
  - Cummins®
  - Johnson-Mistrey®
  - Engelhardt®
  - Siemens®

CHEMICALS

Objective 3: To understand Cummins Filtration's role in DEF supply.

Cummins and Cummins Filtration are working hard to ensure availability of DEF through our dealer and distributor network.

**Fleetguard DEF is available for OEM first-fill as well as aftermarket sales.**



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  - Engelhard®
  - Siemens®

CHEMICALS

**Literature: LT15618 Rev-2**

Objective 3: To understand Cummins Filtration's role in DEF supply.

Fleetguard DEF products are blended from high purity synthetic urea and dissolved in deionized water.



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  - Eng@heart®
  - Siemens®

CHEMICALS

Literature: LT15618 Rev-2

Objective 3: To understand Cummins Filtration's role in DEF supply.

Fleetguard DEF is specifically formulated for SCR protection, providing;

- Longer system life
- Reduced SCR component wear
- Extended SCR catalyst life



**Fleetguard**  
Diesel Exhaust Fluid  
Aqueous Urea Solution for Your SCR NOx Reduction Systems

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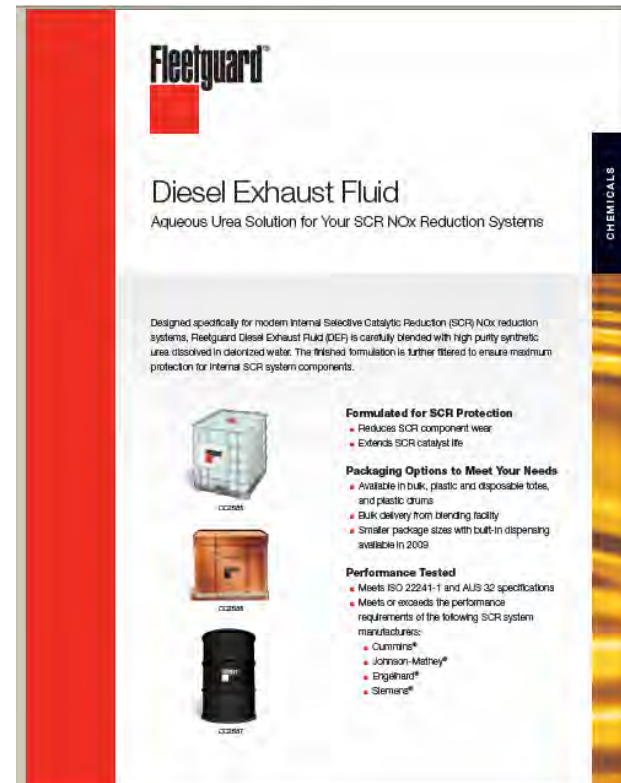
CHEMICALS

Literature: LT15618 Rev-2

Objective 3: To understand Cummins Filtration's role in DEF supply.

Fleetguard DEF is currently available in bulk, plastic and disposable totes, and plastic drums.

**Smaller package sizes of 2.5 and 5 gallon, as well as DEF dispensing equipment will be available soon.**



**Literature: LT15618 Rev-2**

Objective 3: To understand Cummins Filtration's role in DEF supply.

The bulk delivery is available directly from our blending facilities for added convenience, and shipped from Denver, CO, St. Helens, OR, Cheyenne, WY or Chicago, IL.



**Minimum tanker loads are 5000 gallons FOB the blend location.**

Objective 3: To understand Cummins Filtration's role in DEF supply.

CC2584 – Bulk

CC2585 – Plastic 330 gal. tote

CC2586 – Disposable 270 gal. tote

CC2587 – Plastic 55 gal drum

391803400S – Valve/Cutter Kit (for disposable tote)

**Intermediate Bulk Containers (IBC) are containers larger than 55 gallon (207 L) drums.**

**Smaller containers of 2.5 and 5 gallons, as well as DEF dispensing equipment will soon be available.**



CC2586



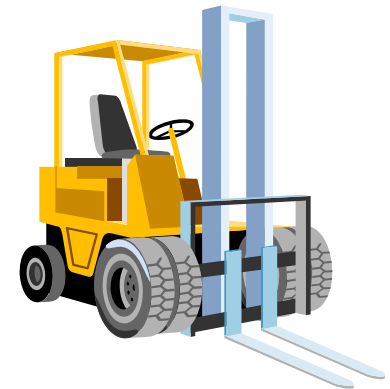
CC2585



CC2587

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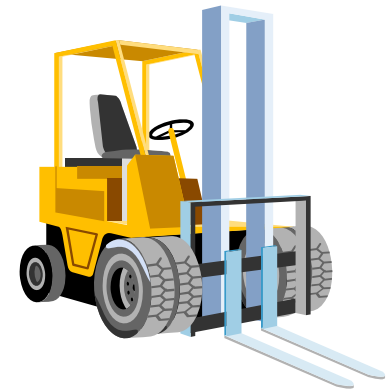
As DEF is not hazardous, it does not require special handling, and can be managed through our existing distribution centers and transportation methods.



**CF has great experience with tote and drum handling with its coolant products.**

Objective 3: To understand Cummins Filtration's role in DEF supply.

DEF is corrosive to some metals, coated metals and other substances. Tank, packaging and dispensing equipment suppliers take this all into account and only use approved materials for their products.



**CF has great experience with tote and drum handling with its coolant products.**

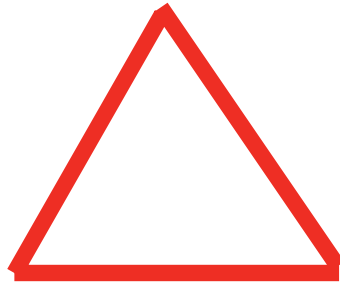


Objective 4: To become familiar with the  
DEF - SCR message triangle.

## DEF Message Triangle

**Cummins Filtration is experienced and knowledgeable about the new SCR system and DEF product.**

- DEF has been available for several years, marketed under the StableGuard Urea brand, and available for order today
- Thousands of SCR equipped Cummins Engines, with millions of miles of use
- Technical support: storage and testing of materials before use and



**DEF is part of the Cummins Filtration value package available to our broad distribution channel providing maximum value to the end user.**

- Over 2,500 retail locations and 20,000 distribution points in NA to support infrastructure of DEF availability
- Cummins Filtration is working closely with customers to ensure they have information and product choices to meet their business requirements

**You can depend on Cummins.**

- The right technology matters - proven products in '98, '02 and 07.
- Customers can depend on Cummins Filtration DEF to be the highest quality – meets ISO2441-1, and AUS32.
- One Cummins - we are only engine and SCR equipment manufacturing company supplying DEF. We can support you from a unique perspective.

**For further information please call:**

***1-800-22FILTER***  
***(1-800-223-4583)***

***For Customer and Technical  
Assistance***